# 1. INTRODUCTION

Experimental Design

Characteristics of Living Things

Homeostasis

## Observations vs Inferences

- ***Observations*** =
  - Noting and recording of FACTS
  - ***Qualitative observations*** =
    - Descriptive characteristics
    - Ex:  Mrs. Amos has brown hair.
  - ***Quantitative observations*** =
    - Numbers obtained through counting or measuring
    - Ex: There are 12 computers in the back of the room.

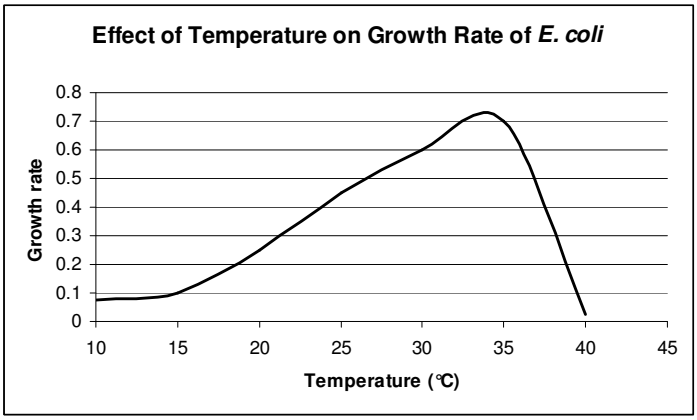
- ***Inferences*** =
  - Logical interpretation based upon prior knowledge and experience
  - Based upon observations
  - Ex: Mrs. Amos is in a good mood. (based on the observation that she is smiling)

- Detailed *observations* should be recorded when collecting data
- *Inferences* may be used when drawing conclusions

## Controls and Variables

- ***Control*** = constant
- ***Variable*** = varies

- Only **ONE** factor should be changed at a time
  - ***Independent (or manipulated) variable*** =
    - Factor in a controlled experiment that is deliberately changed
  - ***Dependent (or responding) variable*** =
    - Factor being observed that changes in response to the independent variable




- Independent variable = temperature
  - Found on x-axis
- Dependent variable = growth rate
  - Found on y-axis

- **ALL** other factors should remain constant
  - ***Control group*** =
    - Exposed to same conditions as experiment group except for ONE independent variable
- Example
  - If variable is temperature
  - Then controls could include
    - Type of bacteria
    - Size of petri dish
    - Nutrient broth given

## Hypotheses vs Theories vs Laws

- ***Hypothesis*** =
  - Possible answer to a scientifically testable question
- ***Theory*** =
  - Well-tested explanation that enables scientists to make accurate predictions
  - Never been shown to be false
  - Ex: Theory of Evolution, Big Bang Theory, Theory of Relativity
- ***Law*** =
  - Generalizes a body of observations
  - Describes things but does not explain them
  - Basis of scientific principles
  - Ex: Newton's Laws of Motion, Mendel's Laws of Inheritance

## Characteristics of Life

All living things…

1. Are made up of cells
2. Are based on a universal genetic code
   - Hereditary information stored in **DNA**
3. Obtain and use energy
4. Grow AND develop
5. Reproduce
6. Respond to the environment
7. Maintain a stable internal environment
   - **Homeostasis**: balance!
8. Change over time

## Homeostasis

- ***Homeostasis*** = ("homeo" means "the same")
  - Relatively constant internal physical and chemical conditions that organisms maintain
  - Thermoregulation (temperature)
    - Sweating vs shivering
    - Dilation vs constriction of blood vessels
  - Osmoregulation (water)
    - Kidneys retain or release more water
    - Guard cells open/close stomata in plants

  - Blood sugar (glucose) levels
    - Pancreas secretes
      - Insulin
        - » If blood sugar is high
        - » Glycogen is synthesized from excess glucose
      - Glucagon
        - » If blood sugar is low
        - » Breaks down glycogen into glucose
  - Gas exchange
    - If $O_2$ levels drop and/or $CO_2$ levels rise
      - Breathe faster and deeper
      - Heart pumps blood (carrying gases) faster

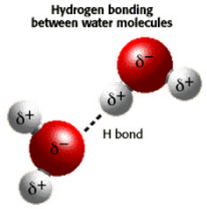
- Note: Large surface area is important for efficient exchange of materials
  - Alveoli increase surface area in lungs for more efficient exchange of gases ($O_2$ and $CO_2$)
  - Capillaries increase surface area of blood vessels for more efficient gas/nutrient exchange
  - Microvilli increase surface area in small intestine for more efficient nutrient absorption
  - Cristae increase surface area of mitochondria for more efficient production of ATP
  - Many small cells are more efficient than large when it comes to diffusion due to larger surface area to volume ratio

# 2. CHEMISTRY OF LIFE

Chapter 2

# Properties of Water

- Polarity
  - Negative pole near oxygen atom
  - Positive pole between hydrogen atoms



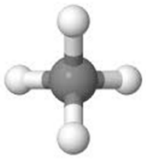

- Bonding
  - Polar molecules (like water) can attract each other
  - ***Hydrogen bond*** =
    - Weak attraction between hydrogen atom and another atom
    - Not as strong as covalent or ionic bonds

- Water's special properties
  - Water expands slightly at freezing point (0℃)
    - Ice is less dense than water
    - Ice floats, insulating water below it
  - Water dissolves ionic compounds and other polar molecules
  - ***Cohesion*** =
    - Attraction between molecules of the same substance
    - Water molecules are drawn together
      - Produces surface tension
      - Some insects can "walk on water"

- ***Adhesion*** =
  - Attraction between molecules of different substances
  - Ex: Adhesion between water and straw causes water to rise
    - Called capillary action
    - Draws water out of plant roots into stem/leaves
- High ***Specific Heat Capacity*** =
  - Amount of heat energy required to increase temperature
  - Allows large bodies of water to absorb lots of heat with only small changes in temp

# Carbon Compounds

- ***Organic*** = contains carbon chains
- Carbon is very versatile because it can form 4 covalent bonds
  - Can bond to other carbons to form long, complex chains
  - Can bond with many different elements
    - In carbohydrates and lipids, carbon bonds with other carbons, hydrogen, oxygen
    - In nucleic acids, carbon bonds with nitrogen and phosphorus (as well a C, H, O)
    - In proteins, carbon bonds with nitrogen and sulfur (as well a C, H, O)
- ***Monomers*** =
  - Smaller units; building blocks
- ***Polymers*** =
  - Composed of many monomers to make macromolecules



- ***Hydrolysis*** =
  - Splits polymers into monomers
  - Bonds are *broken* through the *addition* of water
- ***Dehydration synthesis*** =
  - Joins monomers into polymers
  - *Forms* bonds through the *removal* of water

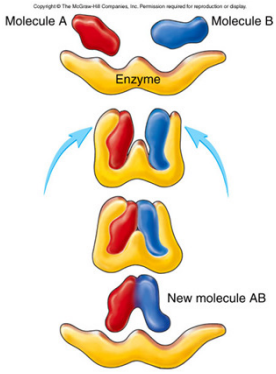
| Macromolecule/ Polymer | Monomer | Function |
|---|---|---|
| Carbohydrates (Polysaccharides) Ex: Starch, Cellulose | Monosaccharides (simple sugars) Ex: Glucose | Energy |
| Lipids Ex: Fats, Oils, Waxes, Phospholipids,Steroids | Glycerol and Fatty acids | Energy Pad, Insulate Cell Membranes |
| Nucleic Acids Ex: DNA and RNA | Nucleotides | Heredity Protein Synthesis |
| Proteins/ Polypeptides | Amino Acids | Enzymes, Antibodies Repair/Maintenance Transportation/ Storage Energy, Hormones |

## Chemical Reactions and Enzymes

- ***Chemical reactions*** =
  - Change one set of chemicals into another
  - ***Reactants*** =
    - Enter chemical reactions
  - ***Products*** =
    - Produced by chemical reactions
- Energy is released or absorbed whenever chemical bonds are formed or broken

- ***Activation energy*** =
  - Energy necessary to start a chemical reaction
- ***Catalyst*** =
  - Substance that speeds up the rate of a chemical reaction
  - Lowers reaction's activation energy
- ***Enzymes*** =
  - Proteins that act as catalysts
  - Speed up chemical reactions in cells
  - Are NOT permanently changed, so they can be reused

- ***Substrates*** =
  - Reactants in an enzyme-catalyzed reaction
  - Bind to active site on the enzyme
  - Converted to product
- Shape of enzyme is important!
  - Complementary to substrate
  - Certain enzymes only fit certain substrates for certain reactions
    - Lock and key




- As the reaction progresses, what happens to the concentration of each?
  - Reactant/Substrate
    - Concentration decreases
  - Product
    - Concentration increases
  - Enzyme
    - Concentration stays the same

- What affects the rate of a chemical reaction?
  - Enzyme concentration
    - More enzyme = faster rate (if there is enough substrate)
  - Substrate concentration
    - More substrate = faster rate (if there are enough enzymes)
  - Temperature and pH
    - Each enzyme has an optimum temperature and pH at which if functions
    - Increasing temp gradually may increase rxn rate
    - Changing pH or adding too much heat can ***denature*** the protein
      - Change in the **shape** of a protein caused by breaking hydrogen bonds
      - Makes proteins nonfunctional

## Enzyme Summary

- Enzymes are proteins
- Enzymes speed up chemical reactions
- They lower the activation energy of a reaction
- Enzymes do not get used up
- Enzymes are specific
- Heat and pH change the shape and function of enzymes

# 3. CELL STRUCTURE AND FUNCTION

Chapter 7

## Organelles

- ***Nucleus*** =
  - Control center
  - Contains chromosomes
    - Carry genetic information (DNA)
- ***Ribosomes*** =
  - Proteins are produced here

- ***Endoplasmic reticulum*** =
  - Transports proteins and lipids
  - Rough er has ribosomes attached
  - Smooth er does not
    - Also involved in lipid synthesis and detoxification of drugs
- ***Golgi apparatus*** =
  - Modifies, sorts, packages, and secretes proteins and lipids from the ER

- ***Vacuoles*** =
  - Store water and other materials
  - Plants have large central vacuole
- ***Vesicles*** =
  - Store and move materials between organelles and cell surface
- ***Lysosomes*** =
  - Vesicles containing digestive enzymes that clean up the cell
  - Typically found only in animal cells

- ***Cytoskeleton*** =
  - Helps cell maintain shape
  - Involved in movement of and within cell

- ***Centrioles*** =
  - Facilitate movement of chromosomes during cell division
  - Found only in animal cells

- ***Chloroplasts*** =
  - Convert energy from sunlight into chemical energy (glucose) through photosynthesis
  - Found in plants

- ***Mitochondria*** =
  - Convert chemical energy from food into ATP during respiration
  - Inner folds increase surface area to produce more ATP

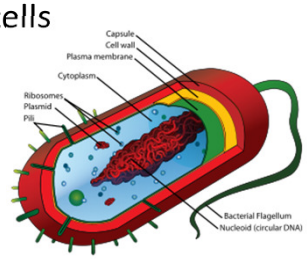
- ***Cell wall*** =
  - Supports, shapes, and protects cell
  - Found in prokaryotes and plant cells
  - NOT found in animal cells

- ***Cell membrane*** =
  - Regulates what enters and leaves cell
  - Composed of lipid bilayer
    - Small, nonpolar, noncharged molecules pass through lipids more easily
      - Ex: Oxygen, carbon dioxide, hydrophobic substances (cholesterol)
    - Large, polar, charged molecules need help of proteins
      - Ex: Sugars and starch, water, $Na^+$ and $K^+$ ions

## Compare and Contrast

- All cells have
  - ***Cell membrane*** =
    - Thin, flexible barrier surrounding cell
    - Controls what enters and leaves cell
  - ***Cytoplasm*** =
    - Jelly-like fluid inside cell
  - ***Ribosomes*** =
    - Site of protein synthesis
    - Found throughout cytoplasm
  - DNA
    - Genetic material of the cell

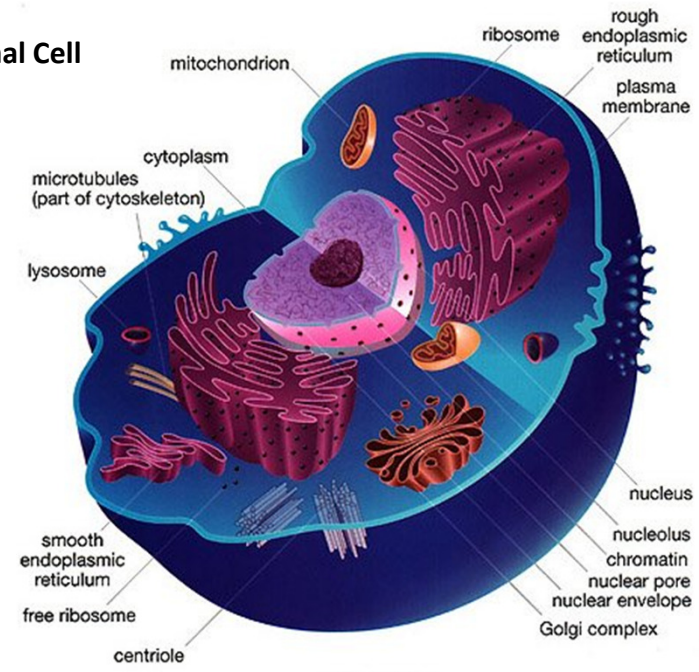
- ***Prokaryotes*** =
  - Unicellular organisms that lack a nucleus
  - DNA is found in cytoplasm
  - Generally smaller and simpler cells
  - Ex: Bacteria



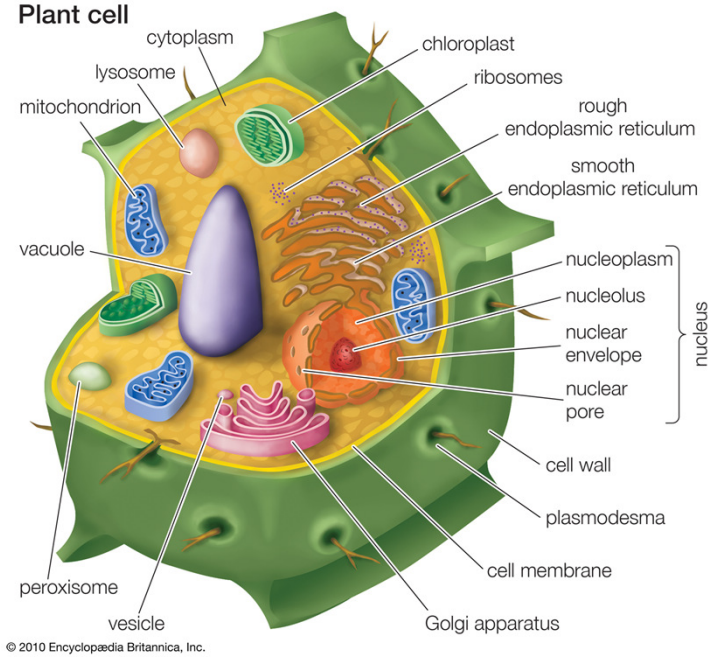

- ***Eukaryotes*** =
  - Cells contain a nucleus
  - DNA is enclosed within nucleus
  - Generally larger and more complex
  - Ex: Protists (unicellular);
    Fungi, Plants, Animals (multicellular)

- Found in plants but NOT animals
  - Chloroplast
  - Cell wall
- Found in animals but NOT plants
  - Lysosomes
  - Centrioles
- Plants have larger, central vacuole

**Animal Cell**




**Plant cell**



# Cell Transport

- ***Passive Transport*** =
  - Movement of materials across cell membrane from ***high to low*** concentration
  - Does NOT require energy

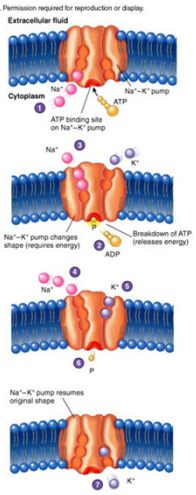
  1. ***Diffusion*** =
     - Movement of solute from ***high to low*** concentration
     - ***Facilitated diffusion*** - requires help of a protein

  2. ***Osmosis*** =
     - The diffusion of water across a selectively permeable membrane
     - Water moves from ***high to low***

- If a cell is placed in a
  - **Hypertonic** solution
    - Water moves out of cell
  - **Hypotonic** solution
    - Water moves into cell
    - Ideal for plant cells
  - **Isotonic** solution
    - Water moves in and out of cell
    - Cells neither swell nor shrink
    - Ideal for animal cells

- ***Active Transport*** =
  - Movement of materials from ***low to high*** concentration
  - Requires ***energy!***

1. Molecular transport via protein pumps
   - ATP provides necessary energy
   - Ex: Sodium-potassium pump
     - Moves Na+ out of cells
     - Moves K+ into cells




2. Bulk Transport
   - ***Endocytosis*** =
     - Taking material into cell through formation of vesicles
   - ***Exocytosis*** =
     - Elimination of material from a cell through the formation of vesicles

## Transport Moves Substances

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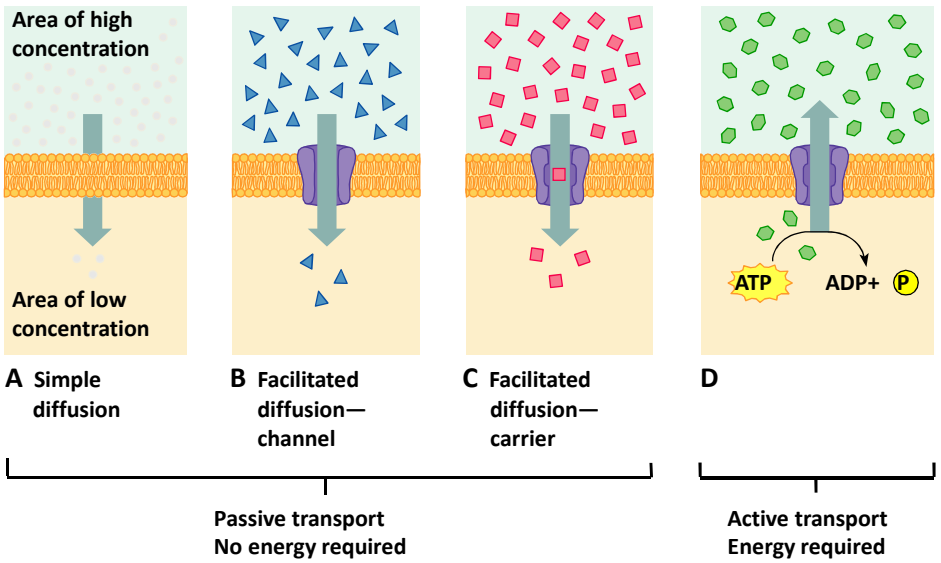




## Endocytosis and Exocytosis

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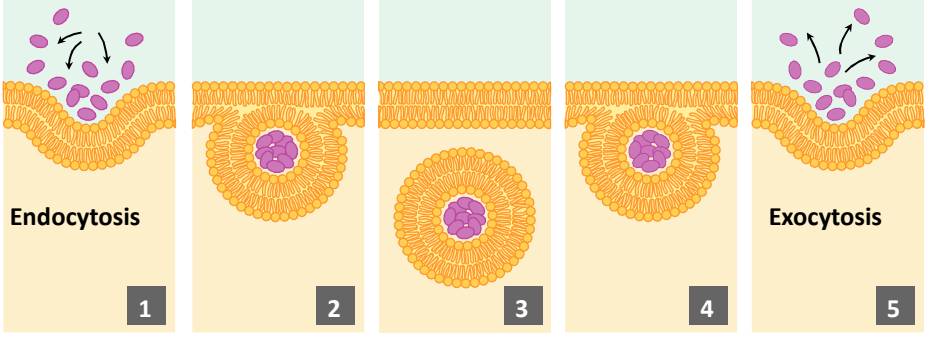


# 4. PHOTOSYNTHESIS AND RESPIRATION

Chapters 8 and 9

## ATP

- Adenosine Triphosphate (ATP)
  - Stores and provides energy
- Energy is released when ATP is broken down into ADP and a phosphate
  - Energy released can be used to do work for
    - Dehydration synthesis reactions
    - Active transport

## Photosynthesis vs Cellular Respiration

- Photosynthesis
  - Reactants
    - Sunlight, Water, Carbon Dioxide
  - Products
    - Sugars (glucose), Oxygen
- Respiration
  - Reactants
    - Glucose, Oxygen
  - Products
    - Carbon Dioxide, Water, Energy (ATP)

- Similarities
  - Both transform energy
  - Both exchange gases
  - Both occur in plants
- Differences
  - Energy flows in opposite directions
    - Photosynthesis converts light energy into chemical energy (glucose)
    - Cellular respiration converts chemical energy from food (glucose) into ATP
  - Gases exchanged in opposite directions
    - Photosynthesis uses $CO_2$ and releases $O_2$
    - Respiration uses $O_2$ and releases $CO_2$

- Photosynthesis occurs in plants, algae, and some bacteria
  - Energy conversion occurs in chloroplasts
- Cellular respiration occurs in nearly all living organisms
  - Energy conversion occurs primarily in mitochondria
  - Note: Some organisms use *fermentation* instead to produce energy in the absence of oxygen

- ***Fermentation*** =
  - The process by which cells release energy in the absence of oxygen
    - Anaerobic
  - Occurs in cytoplasm
  - Examples:
    - Lactic acid fermentation
    - Alcoholic fermentation
      - Produces alcohol and carbon dioxide

# 5. CELL GROWTH AND DIVISION

Chapter 10

- ***Asexual reproduction*** =
  - Genetically identical offspring produced from a single parent
  - Increases population quickly
  - Ex: Bacteria, some plants and simple animals (hydra)
- ***Sexual reproduction*** =
  - Cells from 2 parents unite to form first cell of new organism
  - Increases genetic diversity
  - Ex: Most plants and animals

## Cell Division in Eukaryotes

- ***Mitosis*** =
  - Forms new body cells for growth and tissue repair
  - Produces 2 identical diploid somatic cells
- ***Meiosis*** =
  - Forms sex cells for reproduction
  - Produces 4 genetically different haploid gametes
    - Crossing over and independent assortment contribute to genetic diversity
    - Fertilization of gametes restores diploid number
- ***Apoptosis*** =
  - Programmed cell death
- Coordination of cell division and apoptosis maintains cell numbers

## Cell Cycle

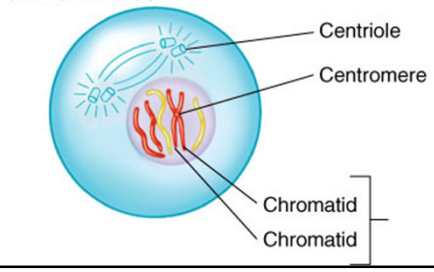
- ***Interphase*** (between cell divisions)
  - Gap phases ($G_1$ and $G_2$)
    - Cell grows
    - Proteins and lipids are produced
  - Synthesis phase (S)
    - Chromosomes are copied
- Cell division
  - ***Mitosis*** = division of nucleus
    - 2 identical daughter cells produced
    - Broken down into 4 phases
  - ***Cytokinesis*** = division of cytoplasm

# Phases of Mitosis

**1. <u>P</u>rophase**

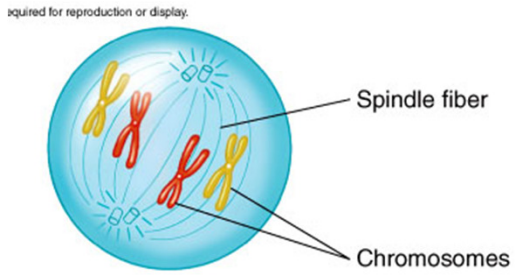
- First phase of mitosis
- DNA coils tightly and chromosomes become visible
  - Each chromosome is composed of 2 identical strands called ***<u>sister chromatids</u>*** =
    - Identical copies of the same chromosome
  - **<u>P</u>**aired sister chromatids are attached along ***<u>centromere</u>***
- Nuclear envelope breaks down





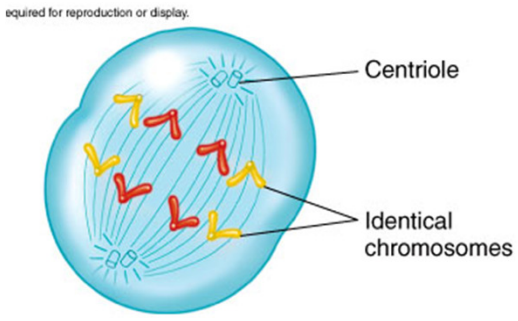
2. **M**etaphase

- Second phase of mitosis
- Chromosomes line up across **M**iddle of cell




3. **A**naphase

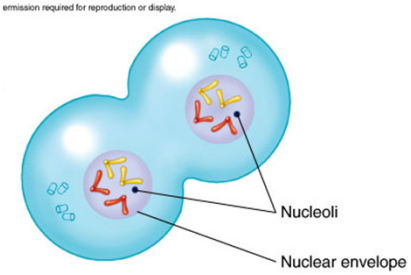
- Third phase in mitosis
- Chromatids separate and move **A**part toward the centrioles at each end of the cell



4. **T**elophase

- Fourth phase of mitosis
- **T**wo nuclear envelope reform (one at each end)



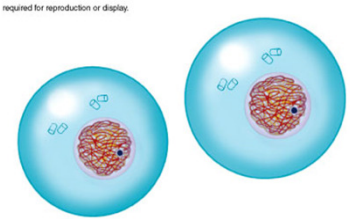



# Cytokinesis

Mitosis is followed by ***cytokinesis*** =

- Division of the cytoplasm and its components
- Animal cells
  - Cell membrane pinches inward
- Plant cells
  - Cell plate forms between 2 nuclei

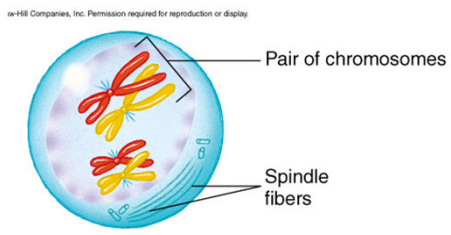




# Phases of Meiosis

## **P**rophase I

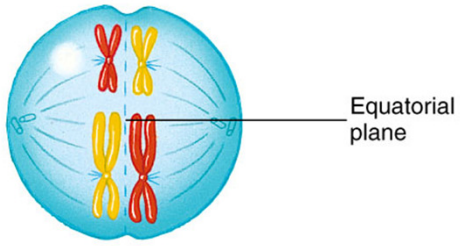
- Replicated chromosomes condense and become visible
- Nuclear envelope fragments
- ***Crossing over*** =
  - Homologs exchange parts
  - Increases genetic diversity!



# **M**etaphase I

- Paired homologs line up across **M**iddle of cell
- ***Independent assortment*** =
  - Random alignment of homologs
  - Increases genetic diversity!

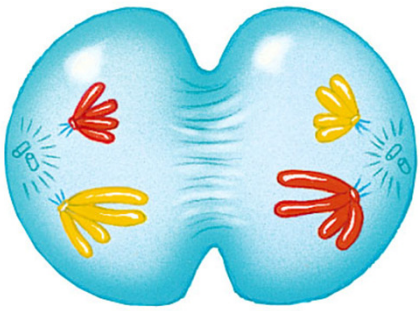





# **A**naphase I

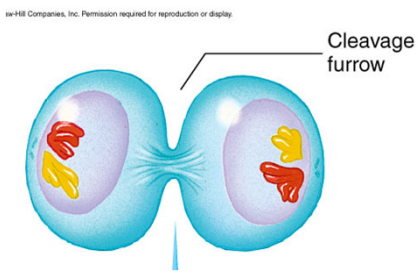
- Homologs move **A**part to opposite poles of cell





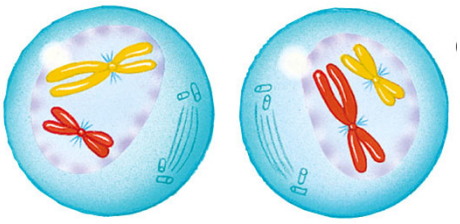
# Telophase I

- Two nuclear envelopes partially assemble around chromosomes on either side of cell
- Cytokinesis divides cell into two




# Prophase II

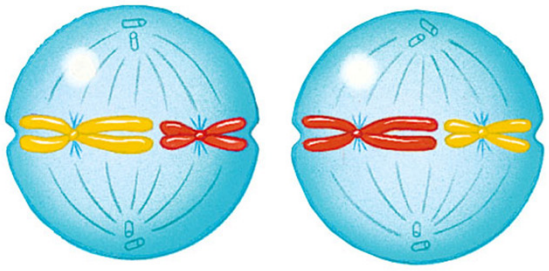
- Chromosomes are again condensed and visible
- Nuclear envelope fragments



# Metaphase II

- Replicated chromosomes line up across middle of cell

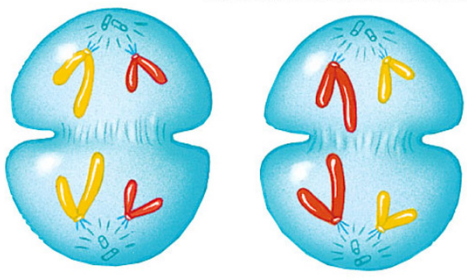




# Anaphase II

- Sister chromatids separate and move apart to opposite poles

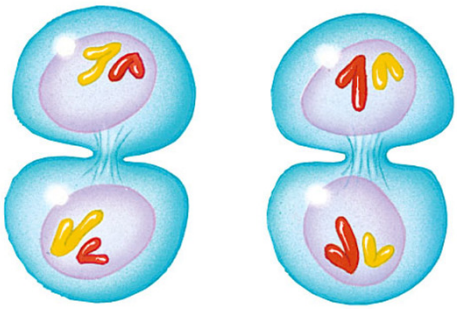




# Telophase II

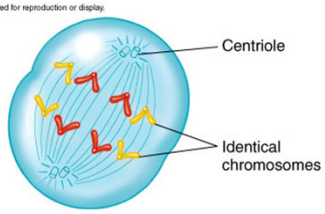
- Nuclear envelopes form around 4 nuclei
- Spindle disappears
- Cytokinesis divides cells into 4
- Result:
  - 4 cells
  - Nonidentical
  - Haploid



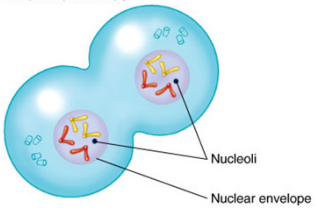


# Name the Phase of Mitosis

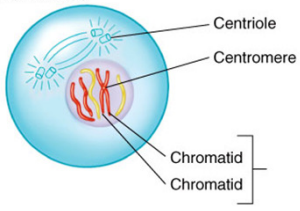




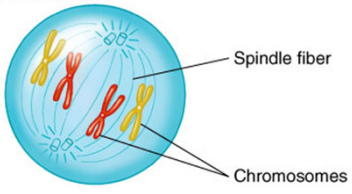


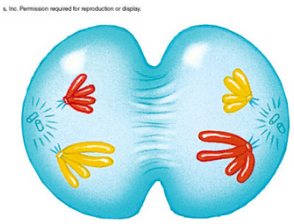


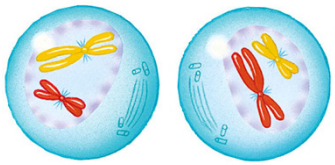



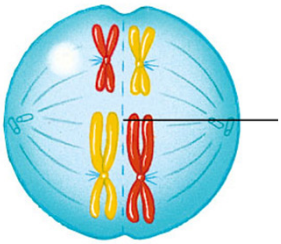


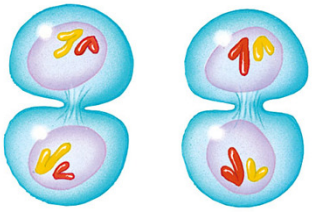



# Name the Phase of Meiosis

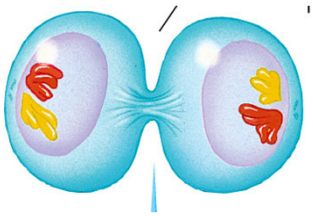


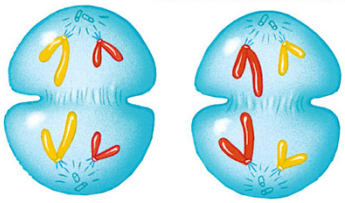


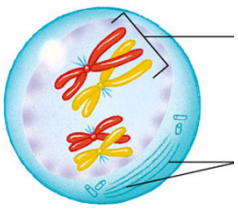


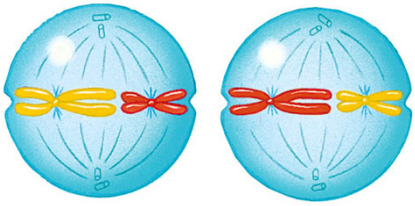


# Name the Phase of Meiosis









| Mitosis | Meiosis |
| --- | --- |
| • One division | • Two divisions |
| • 2 daughter cells | • 4 daughter cells |
| • Daughter cells genetically identical | • Daughter cells genetically different |
| • Chromosome # of daughter cells same as that of parent cell (diploid) | • Chromosome # of daughter cells half that of parent cell (haploid) |
| • Occurs in body cells | • Occurs in reproductive cells |
| • Used for growth, repair, and asexual reproduction | • Used for sexual reproduction, producing new gene combinations |

# Errors in Cell Division

- ***Nondisjunction*** =
  - Homologous chromosomes do not separate properly
  - Error in anaphase
  - Results in abnormal chromosome number
  - ***Monosomy*** =
    - One missing chromosome
  - ***Trisomy*** =
    - One extra chromosome

- Nondisjunction of autosomes could result in:
  - Down syndrome (Trisomy 21)
    - Mental retardation and birth defects
  - Edward syndrome (Trisomy 18)
  - Patau syndrome (Trisomy 13)
- Nondisjunction of sex chromosomes could result in:
  - Turner syndrome (XO)
    - Sterile female
  - Klinefelter syndrome (XXY)
    - Male (typically unable to reproduce)
  - Note: Y with no X won't even be born

# 6. GENETICS

Chapter 11

Punnett Squares and Pedigrees

## Useful Genetics Vocabulary

- ***Alleles*** =
  - Various forms of a gene
- ***Dominant*** =
  - An allele expressed when present in one copy
  - Represented with a capital letter
- ***Recessive*** =
  - An allele whose expression is masked by another allele
  - Represented with a lowercase letter

- ***Homozygous*** =
  - An organism with two identical alleles for a gene
  - True-breeding
- ***Heterozygous*** =
  - An organism that has two different alleles for a gene
  - NOT true-breeding
- ***Phenotype*** =
  - Physical appearance
- ***Genotype*** =
  - Genetic makeup

## Patterns of Inheritance

- ***Complete dominance*** =
  - In the heterozygote, the dominant allele masks the recessive allele
    - The phenotypes of the heterozygote and dominant homozygote are identical

- ***Incomplete dominance*** =
  - Neither allele is dominant, so rather than "masking," "blending" occurs
  - Ex: Flower color in snapdragons
    - RR = Red, WW = White, RW = Pink

- ***Codominance*** =
  - Both alleles are fully expressed
  - Ex: Coat color in cattle
    - RR = Red
    - WW = White
    - RW = Roan (Red AND White)
  - Ex: Sickle cell disease
    - AA = normal red blood cells
    - aa = sickle cell shaped red blood cells
    - Aa = ½ red blood cells are normal and ½ are sickle cell shaped

- ***Multiple Alleles =***
  - A gene that has more than 2 *alleles*
  - EX: Blood types

    $I^AI^A$ or $I^Ai$ = Type A  $I^BI^B$ or $I^Bi$ = Type B

    $I^AI^B$ = Type AB  ii = Type O

- ***Polygenic inheritance =***
  - Trait controlled by 2 or more *genes*
  - Ex: Skin color, hair color, eye color in humans

## Complete Dominance (Mendelian Inheritance)

Tall (T) is dominant over short (t)

Cross the following:
2 heterozygous tall plants

Tt x Tt

| | T | t |
|---|---|---|
| T | TT | Tt |
| t | Tt | tt |

Probability offspring is tall? 3/4
Probability offspring is short? 1/4

Cross the following:
A heterozygous tall plant with a short plant

Tt x tt

| | t | t |
|---|---|---|
| T | Tt | Tt |
| t | tt | tt |

Probability offspring is tall? 1/2
Probability offspring is short? 1/2

## Incomplete Dominance

Red flowers (R) are incompletely dominant over white flowers (W); The heterozygote RW = pink

Cross the following:
2 pink flowers

RW x RW

| | R | W |
|---|---|---|
| R | RR | RW |
| W | RW | WW |

Probability offspring is pink? 1/2
Probability offspring is red? 1/4
Probability offspring is white? 1/4

Cross the following:
A red flower with a white flower

RR x WW

| | W | W |
|---|---|---|
| R | RW | RW |
| R | RW | RW |

Probability offspring is pink? 100%
Probability offspring is red? 0
Probability offspring is white? 0

## Codominance

Red coat color (R) is codominant with white coat color (W);
The heterozygote RW = roan (red AND white)

Cross the following:
A red cow and a white bull

RR x WW

| | W | W |
|---|---|---|
| R | RW | RW |
| R | RW | RW |

Probability offspring is roan? 100%
Probability offspring is red? 0
Probability offspring is white? 0

Cross the following:
A roan cow with a roan bull

RW x RW

| | R | W |
|---|---|---|
| R | RR | RW |
| W | RW | WW |

Probability offspring is roan? 1/2
Probability offspring is red? 1/4
Probability offspring is white? 1/4

# Multiple Alleles

## Blood Types:

$I^AI^A$ and $I^Ai$ = A  $I^BI^B$ and $I^Bi$ = B

$I^AI^B$ = AB  ii = O

Cross the following:
Heterozygous A with Heterozygous B

$I^Ai \times I^Bi$

| | $I^B$ | i |
|---|---|---|
| $I^A$ | $I^AI^B$ | $I^Ai$ |
| i | $I^Bi$ | ii |

Probability offspring has type A? 1/4
Probability offspring has type B? 1/4
Probability offspring has type AB? 1/4
Probability offspring has type O? 1/4

Cross the following:
Type AB with Type O

$I^AI^B \times ii$

| | i | i |
|---|---|---|
| $I^A$ | $I^Ai$ | $I^Ai$ |
| $I^B$ | $I^Bi$ | $I^Bi$ |

Probability offspring has type A? 1/2
Probability offspring has type B? 1/2
Probability offspring has type AB? 0
Probability offspring has type O? 0

# Sex-Linked

## Colorblindness is a recessive X-linked disorder

$X^NX^N$ and $X^NX^n$ = normal female  $X^NY$ = normal male

$X^nX^n$ = colorblind female  $X^nY$ = colorblind male

Cross the following:
Heterozygous normal female and normal male

$X^NX^n \times X^NY$

| | $X^N$ | Y |
|---|---|---|
| $X^N$ | $X^NX^N$ | $X^NY$ |
| $X^n$ | $X^NX^n$ | $X^nY$ |

Probability offspring is normal? 3/4
Probability offspring is colorblind? 1/4

Cross the following:
Heterozygous normal female and colorblind male

$X^NX^n \times X^nY$

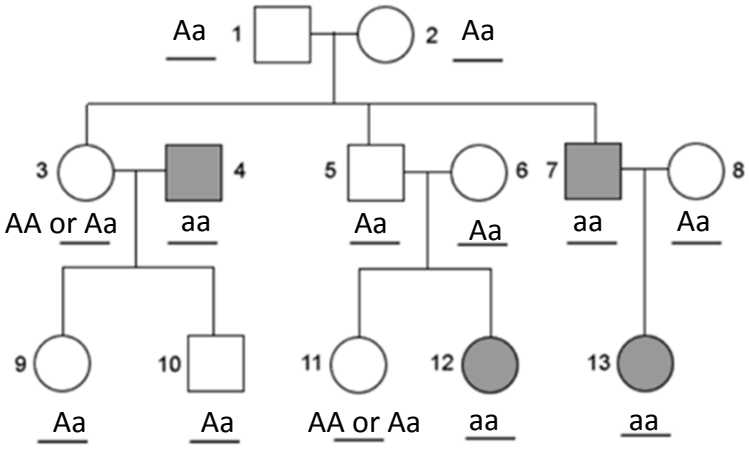
| | $X^n$ | Y |
|---|---|---|
| $X^N$ | $X^NX^n$ | $X^NY$ |
| $X^n$ | $X^nX^n$ | $X^nY$ |

Probability offspring is normal? 1/2
Probability offspring is colorblind? 1/2

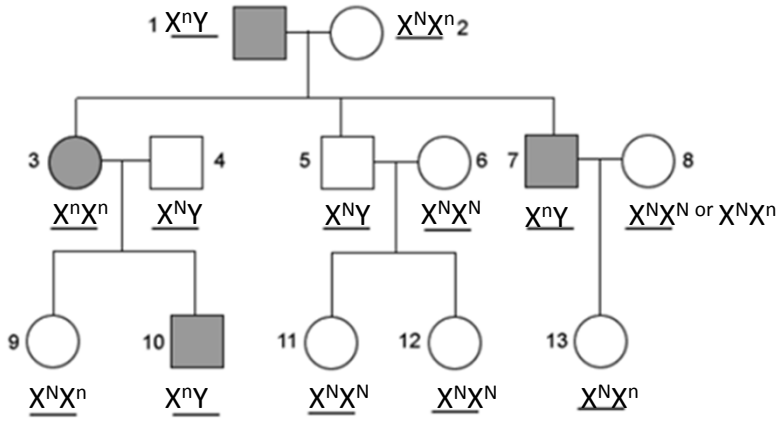
# Pedigrees

- ***Pedigree*** =
  - A family tree that describes the interrelationships of parents and children across generations
  - Can be used to trace inheritance patterns of particular traits
  - Can also be used to make predictions about future offspring
- Key
  - Square = male
  - Circle = female
  - Shaded = affected
  - Half shaded = carrier

This pedigree shows the inheritance of albinism, an **autosomal recessive** trait. Using (A) for dominant and (a) for recessive, solve the genotypes in this pedigree. (Hint: Start with recessive individuals!)



This pedigree shows the inheritance of colorblindness, an **X-linked recessive** trait. Using (N) for normal and (n) for colorblind, solve the genotypes in this pedigree. (Hint: Start with filling in Xs and Ys, then complete the male genotypes, then the recessive females)

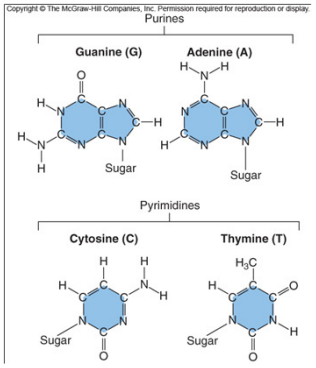



# 7. DNA and Chromosomes

Chapter 12

# Structure of DNA

- Building blocks of nucleic acids = ***nucleotides***
  - 1 sugar (deoxyribose)
  - 1 phosphate group
  - 1 nitrogenous base
    - Adenine (A)
    - Guanine (G)
    - Cytosine (C)
    - Thymine (T)




- Nucleotides join to form long chains
  - Sugar-phosphate backbone
    - Strands are antiparallel
    - 5 prime (5') and 3 prime (3') ends
  - Nitrogenous bases held to those of 2nd strand by weak hydrogen bonds
    - Complementary base pairs
      - **A bonds with T**
      - **C bonds with G**
- Double helix forms when antiparallel, base-paired strands twist

- ***Semiconservative replication*** =
  - Each replicated DNA molecule has one original strand and one new strand
    - IE-One strand of DNA acts as a template for the other strand
- Overview
  1. Strands unwind and separate at several points
  2. ***DNA polymerase*** adds complementary bases to template
     - **A with T and vice versa**
     - **G with C and vice versa**
  3. Sugar-phosphate backbones seal back up
- Result
  - 2 DNA molecules
  - Identical to each other and original

- DNA Replication occurs during the S phase of the cell cycle
- DNA polymerase works directionally
  - Only adds new nucleotides to exposed 3' end
  - Replication proceeds in a 5' to 3' direction
  - Replication on one strand is continuous
  - The other is discontinuous
    - Produces small pieces called ***Okazaki fragments***

## DNA Replication Practice

- DNA template strand

  C C T A G C T A C
- Replicated strand

  G G A T C G A T G

# 8. RNA and PROTEIN SYNTHESIS

Chapter 13

| DNA | RNA |
| --- | --- |
| • Double stranded<br>• Thymine<br>• Sugar is Deoxyribose | • Single stranded<br>• Uracil<br>• Sugar is Ribose |

- Types of RNA
  1. Messenger RNA (mRNA)
     - Carries copies of instructions from DNA to ribosomes
     - Contains codons
  2. Ribosomal RNA (rRNA)
     - Important component of ribosomes
  3. Transfer RNA (tRNA)
     - Carries amino acids to ribosomes during protein synthesis
     - Contains anticodons

- ***Transcription*** =
  - Synthesis of RNA from DNA template
  - Eukaryotes
    - Occurs in nucleus
  - Prokaryotes
    - Occurs in cytoplasm

- ***Translation*** =
  - mRNA is converted into sequence of amino acids of a protein
  - Eukaryotes AND prokaryotes
    - Occurs in cytoplasm at ribosomes

## Transcription and Translation Practice

- DNA template strand

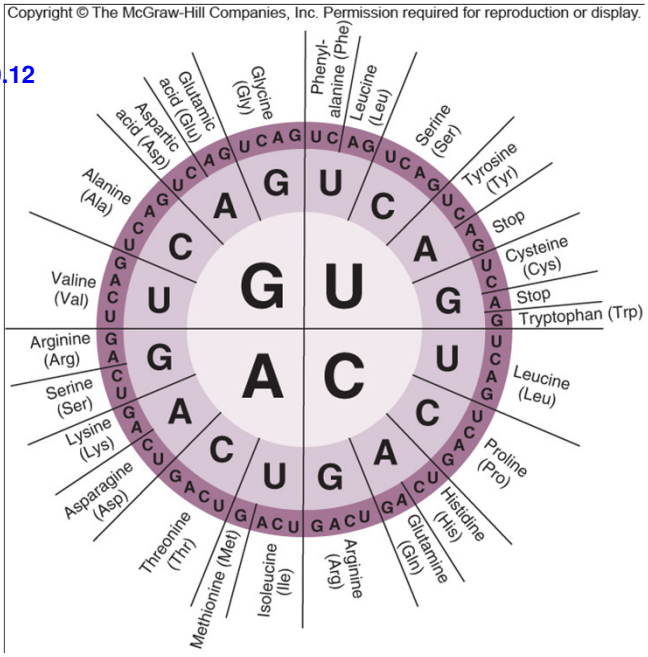
  TACGGTCGTTCGAATATC
- mRNA codons

  AUG CCA GCA AGC UUA UAG
- tRNA anticodons

  UAC GGU CGU UCG AAU AUC
- Amino Acid (remember to use the codons!)

  Met Pro Ala Ser Leu (STOP)

Figure 10.12



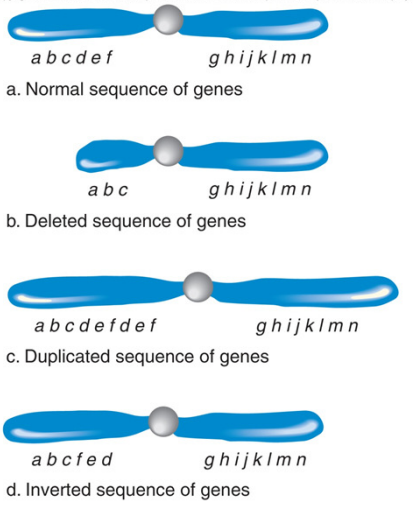

# Mutations

- ***Mutation*** =
  - Change in the genetic material of a cell
    - Alters DNA sequence
    - May or may not affect phenotype
  - Source of variation
    - May increase number of alleles in population
  - 2 basic categories:
    - Chromosomal mutations
    - Gene mutations

## Chromosomal Mutations

- ***Deletion*** =
  - Loss of part of a chromosome
- ***Duplication*** =
  - Extra copy of a part of chromosome
- ***Inversion*** =
  - Reverses direction of parts of chromosome





- ***Translocation*** =
  - Part of one non-homologous chromosome breaks off and attaches to another
- ***Insertion*** =
  - Insertion of a larger sequence into a chromosome
  - Due to unequal crossing over during meiosis

## Gene Mutations

- ***Substitution*** =
  - One base is changed to a different base
  - Results in change of one codon
  - Examples
    - ***Missense mutation*** =
      - One amino acid is altered
    - ***Nonsense mutation*** =
      - Protein is shortened because new codon is a "STOP" codon
    - ***Silent mutation*** =
      - No change in amino acid
      - 3rd base of triplet was altered to codon that specifies the same amino acid

- ***Frameshift mutations*** =
  - Shifts "reading frame" of genetic message
  - Alters every amino acid that follows the mutation
  - Examples
    - ***Insertion*** =
      - One base is added to DNA sequence
    - ***Deletion***
      - One base is removed from DNA sequence
- Note: If bases are inserted/deleted in multiples of 3, reading frame is not altered

- Harmful effects
  - Cancer and other genetic disorders
- Beneficial effects
  - Resistance
  - ***Polyploidy*** = extra sets of chromosomes
    - Results in larger and stronger plants
  - Increase genetic variability in a species
- Many mutations are neutral
  - May not even change any amino acids

# 9. GENETIC ENGINEERING

Chapter 15

- ***Genetic Engineering*** =
  - Manipulating the genetic material to produce desirable functions that would not occur naturally
- Examples:
  - ***Selective breeding*** =
    - The intentional breeding of organisms to produce offspring with certain desirable characteristics
    - Hybridization
      - Ex: Combine disease resistance with food producing capacity
    - Inbreeding
      - Risk: Could increase likelihood of genetic defects

- ***Biotechnology*** =
  - The manipulation of living organisms to produce useful products
  - Introduce mutations to increase variation
- ***Recombinant DNA*** =
  - DNA produced by combining DNA from different sources
  - Restriction enzymes are used to cut the DNA
- ***Cloning*** =
  - Uses single cell of an adult to grow a genetically identical organism
  - Egg cell whose nucleus was removed is fused with a donor cell

## Applications

- Agriculture
  - Produce less expensive and more nutritious food
  - Improve crop resistance to insects and herbicides
  - Increase crop yields without using pesticides
  - Increase milk production and produce leaner meat
- Medicine
  - Preventing and treating disease
    - ***Gene therapy*** =
      - Replacing an absent or faulty gene with a normal working one
  - Medical research
  - Genetic testing

## PROS (+)

- Prevent human diseases through early detection
- Treat and possibly cure diseases
- Reproduce human organs for transplants
- Increase crop resistance to harsh conditions and pests
- Improve taste and nutritional value of crops
- Lower food cost by improving crop yield
- Identify remains of unknown soldiers
- Help solve crimes
- Could increase genetic diversity

## CONS (-)

- Threaten beneficial organisms
- Creation of new pathogens
- Harmful side effects
- Expensive
- Moral/Ethical concerns
  - Health insurance or employment manipulation?
  - "Designer" offspring?
- Irreversible effects with unknown consequences
- Could decrease genetic diversity (ie-cloning)

# 10. ECOLOGY

- ***Biotic factors*** =
  - Living components in the environment
  - Ex: Other organisms that serve as food, predators, competition, etc.
- ***Abiotic factors*** =
  - Chemical and physical components of the environment (nonliving)
  - Ex: Sunlight, temperature, precipitation, pH, salinity, soil type, etc.
- ***Species*** =
  - Group of similar organisms that can breed and produce fertile offspring

- ***Population*** =
  - Group of individuals of the same species that live in the same area
- ***Community*** =
  - Group of different, interacting species that live in the same area
- ***Ecosystem*** =
  - All of the organisms that live together, interacting with their physical environment
- ***Biome*** =
  - Group of ecosystems that share similar climates and typical organisms
  - Grouped geographically

# Biomes

- Tropical Rain Forest
  - Thin, nutrient poor soil
  - Hot; very wet
  - Most diverse!
- Tropical Savanna
  - Frequent fires
  - Hot; dry and wet seasons
- Desert
  - Thin, porous, nutrient poor soil
  - Hot days, cold nights; very dry

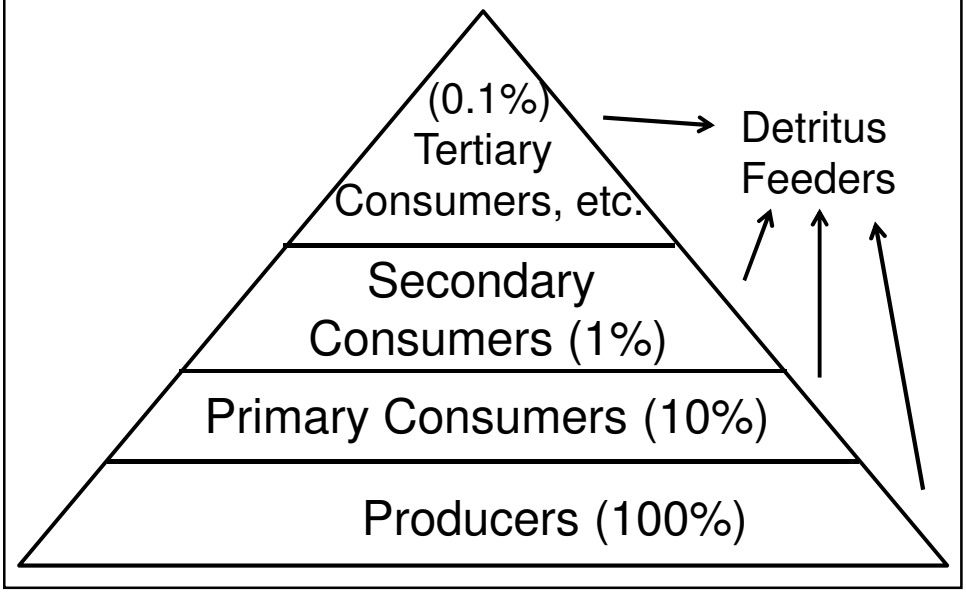
- Temperate Grassland
  - Fertile soil
  - Warm/hot summers, cold winters; moderate precip.
- Temperate Forest
  - Fertile soil
  - Warm/hot summers, cold winters; moderate precip.
- Coniferous Forest
  - Acidic soil
  - Short summers, cold winters; less precip.
- Tundra
  - Permafrost
  - Long, cold winters; low precip.

## Energy Flow

- **Autotrophs/producers**
  - Make their own food
    - Most green plants, algae, bacteria
- **Heterotrophs**
  - **Consumers**
    - Consume living organisms
      - Primary: Herbivores (elephant, rabbit, cow)
      - Secondary: Carnivores (fox, dog, hawk)
      - Tertiary and Quaternary: top predators
  - **Detritus feeders/decomposers**
    - Feed on dead organisms
      - Earthworms, fungi, bacteria

- All food webs must start with producers
- Arrows show flow of ENERGY
- Only 10% of energy is passed from one organism to another
  - Some is broken down to do work
  - Some is lost as heat and waste
- Less energy is available at top of food web

## Biomass and Energy Pyramids



# Interactions

- Organisms avoid competition by developing ***niches*** =
  - Role and position an organism has in ecosystem
  - "Job"
- ***Keystone species*** =
  - Essential for survival of many other species
  - Examples
    - Starfish prevent mussels from crowding out other organisms
    - Otters prevent urchins from eating entire kelp habitat

- ***Parasitism*** =
  - One organism benefits while other is harmed
  - Ex: Tick and dog
- ***Mutualism*** =
  - Both organisms benefit
  - Ex: Clownfish and anemone
- ***Commensalism*** =
  - One organism benefits and other is unaffected
  - Ex: Remora and shark

# Succession

- ***Succession =***
  - Change in the species that occupy an ecosystem
  - Caused by a change in one or more factors that benefits some species at the expense of others
    - Biotic or abiotic
    - Natural or human disturbances
- ***Primary succession*** =
  - Occurs in an area in which no trace of a previous community is present
  - No soil exists
  - Ex: Volcanic eruptions or retreating glaciers
- ***Secondary succession*** =
  - Occurs in area that was only partially destroyed by disturbances
  - Soil still remains
  - Ex: Wildfires, hurricanes, logging, farming

# Population Growth

- Exponential Growth
  - The larger a population gets, the faster it grows
  - J-shaped growth curve
    - Population growth under optimal conditions
    - Eventually crashes
- Logistic Growth
  - Growth slows and then stops following a period of exponential growth
  - S-shaped growth curve
    - Population stabilizes at ***carrying capacity*** =
      - Maximum number of individuals of a species that can be supported by that environment
- ***Limiting Factors*** =
  - Control growth of population
  - Determine carrying capacity
  - Ex: Nutrients (nitrogen and phosphorous)

## Nutrient Cycles

1. Bacteria absorb nitrogen gas from atmosphere and convert it into more usable form through ***nitrogen fixation***
2. Primary producers use this nitrogen to make proteins and nucleic acids
3. Passed through food webs
4. Released in waste and decomposing matter
5. Other bacteria convert it back into nitrogen gas through ***denitrification***

- If soil is lacking nitrogen or phosphorus
  - Less plant growth
  - The missing nutrient is the limiting factor!
  - If that nutrient then gets added to the ecosystem, growth will occur again

- If excess nitrogen or phosphorus is added to bodies of water
  - Causes algal blooms
  - Algae block light, killing underwater plants
  - Bacteria use up oxygen as they break down excess detritus
  - Fish suffocate and die!

# 11. EVOLUTION

- ***Adaptation*** =
  - Characteristic that increases an organism's ability to survive and reproduce in an environment
  - Inherited, NOT acquired
  - Examples
    - To cope with climate: thick fur, hibernation
    - To obtain food and water: long neck, web
    - To defend against predators: camouflage, armor
    - To attract mates: calls, exotic feathers

- ***Natural selection*** =
  - Organisms that are most suited to their environment survive and reproduce
  - Acts only on inherited traits
    - NOT acquired characteristics
  - Mechanism for evolution
  - Ex: Peppered moths

- ***Homologous structures*** =
  - Similar structures in different species of common ancestry
    - Front limbs of vertebrates
  - Supports descent with modification from common ancestor
- ***Analogous structures*** =
  - Share common function, not structure
    - Wing of bee and bird
  - Not the clue to common descent
- ***Vestigial structures*** =
  - Inherited from ancestors but lost much or all of original function

- Populations evolve
  - NOT individuals!
- Mutations are a source of genetic variation
- ***Genetic drift*** =
  - A change in the gene pool of a small population that takes place strictly by chance
    - Does not produce adaptations since it is random
  - Bottleneck and founder effects

- New species can form when they become reproductively isolated
  - ***Behavioral isolation*** =
    - Organisms develop differences in courtship rituals
  - ***Geographic isolation*** =
    - Organisms are separated by physical barriers like water or mountains
  - ***Temporal isolation*** =
    - Organisms reproduce at different times

# Phylogenetic Trees

| Organism | Number of Amino Acids that are Different from Chimpanzee Cytochrome c |
|---|---|
| Dog | 10 |
| Moth | 24 |
| Penguin | 11 |
| Yeast | 38 |
| Human | 0 |